THE EFFECTS OF INDIVIDUAL DIFFERENCES IN PHYSIOLOGICAL REACTIVITY ON LEARNING CONTROL OF EMG AND GSR RESPONSES THROUGH BIOFEEDBACK TRAINING

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CHAPTER I

INTRODUCTION

For many years it was thought to be impossible for humans to control their internal, autonomic processes. However, it has been found that if individuals are provided with information in the form of biofeedback for internal responses such as heart rate, blood pressure, skin resistance, and electrical activity of the brain, they can learn to voluntarily control the physiological responses associated with biofeedback. This discovery has led to a series of research projects investigating the ameliorative effects of biofeedback training upon a wide array of disorders. Results of these many studies have shown biofeedback training to have beneficial effects. For example, heart rate training has been used successfully with individuals with cardiac arrhythmias (Weiss & Engel, 1971).

Feedback of the electromyographic activity (EMG) of muscles has been shown to be useful in relaxation training (Budzynski & Stoyva, 1969) and for the elimination of tension headaches (Budzynski, Stoyva, & Adler, 1970; Budzynski, Stoyva, Adler & Mullaney, 1973). In addition, EMG training has had beneficial results in work with individuals with Central Nervous System disorders of voluntary movement (Brudny, Korein, Levidow, Grynbaum, Lieberman, & Friedmann, 1974). Sensorimotor rhythm training (SMR) using biofeedback has been shown to significantly decrease clinical seizures in epileptics (Finley, Smith & Etherton, 1975; Sterman & Friar, 1972). The above mentioned studies are just a few of the many possible clinical applications of biofeedback training.

With the utility of biofeedback training in working with various disorders increasingly apparent, it becomes important to indicate those factors that contribute to a successful training experience. Many studies have reported considerable individual differences in the amount of learning achieved through biofeedback training (Miller, 1975; Roberts, 1975; McCanne & Sandman, 1976). Researchers have begun to investigate the relationship between several different personality factors and the ease of learning autonomic control, so as to better predict those individuals who are most likely to benefit from biofeedback training (see Appendix A for a literature review of this area).

Only three of the personality variables studied so far appear to consistently differentiate between good and poor learners of autonomic control through the use of biofeedback. The most extensively researched variable in this regard, locus of control, is one of these. Individuals are said to have an internal locus of control if they usually judge reinforcements to be contingent upon their own actions and hence under their own control. External locus of control individuals usually consider reinforcements to be beyond personal control or not contingent upon their actions. A majority of the studies investigating the relationship between locus of control and autonomic learning have found that those subjects with an internal locus of control are better able to learn autonomic control than those subjects with an external locus of control (Fotopoulos & Binegar, 1976; Reinking, Morgret & Tamayo, 1976; Jordan and Schallow, 1975; Johnson & Meyer, 1974; Goesling, May, Lavond, Barnes & Carriera, 1974; Wagner, Bourgeois, Levenson & Denton, 1974). The most notable exception occurs in heart rate conditioning where although internal locus of control subjects were better able to increase their heart rate as compared with externals, external locus of control subjects were better able to decrease their heart rate as compared with internals (Ray & Strupp, 1972; Ray, 1974).

Autonomic perception is another variable that appears to differentiate between good and poor learners of autonomic control. Autonomic perception refers to the degree of awareness individuals feel they have of their internal, autonomic activity and has most often been measured by the Autonomic Perception Questionnaire (APQ) devised by Mandler, Mandler & Uviller (1958). Instead of the expected positive relationship between autonomic perception and autonomic control, a majority of the studies involving this variable have found that individuals with low autonomic perception learn autonomic control more readily than individuals with high autonomic perception (Greene & Nielson, 1966; Blanchard, Young & Macleod, 1972; Whitehead, Drescher & Blackwell, 1976). The exceptions to this are Bergman & Johnson (1971) who found that those subjects with middle autonomic perception scores displayed more heart rate control than those subjects with high or low scores, and Ikeda and Hirai (1976) who found that high autonomic perceivers were best able to control their electrodermal activity. The results of the latter are difficult to interpret as autonomic perception is confounded with imagery in the Ikeda & Hirai study. A possible explanation for the results of these studies is that high autonomic perceivers have been shown to overestimate their autonomic activity. Thus, low or middle APQ scorers may actually be more accurate in their perception of their autonomic activity.

The third variable that appears to relate to autonomic learning is that of anxiety. All of the studies investigating this variable found that low anxiety individuals are better able to learn autonomic control than high anxiety individuals (Goldenthal, 1976; Utz & Banikiotes, 1973; Valle, Chisolm & Degood, 1975).

Several other variables that have been studied appear to be unrelated to autonomic control. All of the studies looking at the relationship between introversion/extraversion and autonomic control have found no differences between introverts and extraverts in their ability to learn autonomic control (Morgenson & Martin, 1969; Travis, Kondo & Knott, 1974; Carlton, 1974). Nor have studies looking at hypnotic susceptibility and autonomic learning found any relationship between the two (Weinstock, 1974; Roberts, Schuler, Bacon, Zimmerman & Patterson, 1975).

It is difficult to say at this point whether several of the other variables studied are or are not related to the ability to learn autonomic control. For example, the two studies looking at the relationship between field dependence/independence and autonomic learning obtained opposite results. Tutone (1974) found field independent subjects were better able to enhance alpha than field dependent subjects, whereas Berger (1974) found that field dependent subjects were better able to control their heart rates than field independent subjects. Although several studies have been done on sex differences in autonomic learning, they have all been done using heart rate and have obtained conflicting results. Young and Blanchard (1972) reported male superiority in ability to raise heart rate, whereas Zimmerman and Blankstein (1975) did not find any differences between the sexes in their ability to control their heart rates. A study by Davidson and Schwartz (1976) did find that males and females appear to use different cognitive strategies in controlling their heart rates. Because of the conflicting results obtained with these two variables, further research is needed to clarify the relationship between autonomic learning and field dependence/independence and sex.

Several other studies have found relationships between various personality variables and the ability to learn autonomic control. Stephens, Harris, Brady, and Shaffer (1976) found that those subjects with high ego strength scores on the Minnesota Multiphasic Personality Inventory (MMPI) were better able to control their heart rate than those with low ego strength scores. Ancoli and Green (1977) found that individuals scoring high in introspection and low in authoritarianism were better able to control their alpha production than those individuals scoring low in introspection and high in authoritarianism. Tafts, Hon, and Blankstein (1974) found that high achievers were able to effect greater control over heart rate increases with feedback, and tended to effect slightly greater although nonsignificant decreases. Scully and Benjamin (1969) found that contrary to their expectations, manually skilled subjects took longer to successfully isolate and maintain single motor units in the hand in regular isolated activity, than did those who were not manually skilled. However, all of the above variables have been investigated in only one study and further research is needed before definitive statements about the relationship of any of these variables with the ability to learn autonomic control can be made.

The results of the aforementioned studies indicate that there does appear to be a relationship between personality and the ability to learn autonomic control. Individuals with certain personality characteristics do seem more likely to benefit from biofeedback training than individuals without these traits. Thus, research investigating the relationship between psychological variables and autonomic learning should contribute considerably to our knowledge of what factors are involved in successful biofeedback training.

It has also been suggested that physiological variables such as autonomic responsivity or labilty are related to individual differences in autonomic learning (Roberts, Schuler, Bacon, Zimmerman & Patterson, 1975; Stephens, Harris, Brady & Shaffer, 1975; Montgomery, 1976). A series of studies by the Laceys and their colleagues (Lacey, Bateman & Van Lehn, 1952, 1953; Lacey & Lacey, 1958, 1970; Lacey & Van Lehn, 1952) have clearly demonstrated that individual subjects respond to stressful situations with patterns of autonomic responses that are highly idiosyncratic. The individuals in Laceys' studies characteristically overresponded in some modalities and underresponded in others. Further research by the Laceys (Lacey & Lacey, 1958, 1970) found that intraindividual patterns of response are stable over time and over a variety of stressors. Thus, there appears to be fundamental differences between individuals in the organization and control of physiological responding to stress.

In a couple of studies investigating individual differences in somatic responses to stress, two groups, one reporting mainly muscular symptoms in response to stress and one reporting mainly autonomic arousal in response to stress, were found to exhibit distinct patterns of autonomic responding (Brandt & Fenz, 1969; Horwath & Fenz, 1971). Brandt and Fenz used the Fenz/Epstein Modified Anxiety Scale (Fenz & Epstein, 1965) to separate individuals into a muscular tension group and an autonomic arousal group. This modified scale includes three subscales. The first contains items related to symptoms of autonomic arousal. This scale referred to visceral symptoms associated with activation of the autonomic nervous system. Items refer to tachycardia, vasomotor reactions, emotionally induced sweating, failure of body temperature control and digestive disorders. The second subscale relates to symptoms of muscular tension. Items in this scale are descriptive of the effects of sustained contraction of striated or voluntary muscle. Included are items referring to tremor, motor incoordination, backache, neckache, rapid breathing, pressure headaches and skin sensitivity. The third subscale contains items relating to subjective feelings of fear and insecurity. Included are items that refer to the inability to concentrate or relax, the tendency to worry excessively over trifles, unexplained feelings of fear and panic, fitful sleep, compulsive mannerisms and stated feelings of insecurity. Subjects were separated into the two groups on the basis of their responses to the first two scales. The autonomic arousal group included 12 female subjects whose autonomic arousal scores were significantly higher than their muscular tension scores. The muscular tension group was made up of 12 female subjects whose muscular tension scores were significantly higher than their autonomic arousal scores. Skin resistance, basal conductance, heart rate, eye blinks and EMG were monitored as these subjects reacted to three conditions: relaxation, moderate stress (white noise), and high stress (threat of shock). The authors discriminated between consistency and statistical significance, with consistency meaning that a group showed consistent, but nonsignificant, responses within the group and across the three treatment conditions. There were consistent group differences on all measures. The muscular tension group was consistently higher than the autonomic group on the heart rate and EMG measures. The autonomic arousal group was consistently higher than the muscular tension group on two of the five recordings of palmer skin resistance: mean basal resistance and mean basal conductance. The autonomic group was also consistently higher than the muscular group on the eye blink measure. No differences were evident between the two groups on the remaining three recordings of palmer skin resistance: average magnitude of the nonspecific galvanic skin response (GSR), cumulative magnitude of the nonspecific GSR, and frequency of the nonspecific GSR.

Horwath and Fenz (1971) replicated the above study, using psychoneurotic patients as subjects. The 24 male and 10 female subjects were again separated into an autonomic arousal and a muscular tension group using the same criterion as the previous study. Six recordings of physiological activity were made: direct and integrated heart rate, skin resistance, striated muscle activity, eye blinks, and respiration rate. Three experimental conditions were presented successively to the subjects: relaxation, moderate stress (threat of annoying noise), and high stress (threat of shock). They found that the male muscle tension group showed a consistently higher direct heart rate (EKG) than the male autonomic arousal group, while the female groups showed a consistently opposite pattern. They found no real differences between the two male groups on respiration, however, female subjects high on self-reported muscular tension had a significantly higher respiration rate than females high on self-reported autonomic arousal. The autonomic groups were consistently higher than the muscular tension groups on the three measures of palmer electrodermal activity: mean basal conductance, cumulative magnitude of nonspecific GSR and frequency of the non-specific GSR's. Both male and female muscle tension groups were consistently higher on the measure of EMG frequency. Although the differences in EMG frequency were not significant for male subjects, significant group differences were obtained for female subjects. In summary, consistent but non-significant differences between groups were found for heart rate and electrodermal measures. Consistent and significant differences were found between groups for measures of muscle tension. The above two studies (Brandt & Fenz, 1969; Horwath & Fenz, 1971) further support the concept of physiological specificity. More specifically, the combined findings of the two studies indicate that those individuals who report autonomic symptoms significantly more than muscular symptoms in response to stress, exhibit consistently different physiological response patterns than those individuals who report significantly more muscular symptoms than autonomic symptoms, across a series of experimental conditions.

A series of biofeedback studies have obtained results which point to the importance of such individual differences in physiological reactivity in effective biofeedback training. Alan le Boef (1974) in a study looking at the importance of individual differences in the treatment of chronic anxiety by EMG biofeedback training, used the Fenz-Epstein Modified Anxiety Scale to separate those individuals who report predominantly autonomic symptoms from those who report predominantly muscular symptoms. Twenty-four subjects were used altogether; 12 in each group. All subjects were given at least three sessions of EMG feedback a week for a period of three months. Relaxation instructions were provided for subjects to practice at home. During all the training sessions, EMG and heart rate were monitored and subjective effects measured before and after each session. It was found that those subjects with muscular symptoms showed significant improvements in both specific symptoms and generalized anxiety at the end of treatment. As a group, the subjects with autonomic symptoms did not show improvement, however, some individuals did appear to benefit. In addition it was found that the muscular symptoms group showed significantly higher frontalis EMG levels than the autonomic group and that during sessions there was a significant correlation between EMG and heart rate change which was more marked for the muscular symptoms group.

Stern and Kaplan (1967) found that college students who displayed the highest degree of control over their GSR's were usually individuals who reported their predominant physiological change during real-life emotional situations was sweating. A study by Stern and Lewis (1968) obtained similar results. They were investigating the relationship between the ability to control GSR and emotional expression in professional actors who had been trained with either of two different acting methods. No relationship was found between the ability to control GSR's and emotional expression as measured by the ratings of the directors. It was found that those actors who normally experience sweating as their primary response to stress diaplayed better voluntary control of their GSR's than non-sweaters.

The above studies are important in that they point to the importance of individual differences in physiological responsivity in both autonomic control and the effectiveness of biofeedback training. However, none of these studies offers any direct evidence that those individuals who are more responsive in one physiological modality are better able to learn control over that modality than individuals who are more responsive in a different modality.

The Present Study

The present study proposes to further explore the relationship of individual differences in physiological responsivity and the ability to learn autonomic control by comparing the biofeedback performance of individuals who exhibit predominantly muscular reactions to stress (as measured by the Fenz-Epstein Modified Anxiety Scale) with those individuals who exhibit predominantly autonomic symptoms. All subjects will be given both EMG and GSR biofeedback training, and their learning abilities in the two modalities will be compared. It is hypothesized that autonomic control will be learned more readily in that modality in which the individual is more responsive. More specifically, it is hypothesized that those individuals who report more muscular tension in response to stress will learn to decrease their EMG levels better than those individuals who report more autonomic symptoms in response to stress. It is also hypothesized that those individuals who report more autonomic symptoms in response to stress will learn to decrease their GSR responses better than those individuals who report primarily muscular symptoms.

The third subscale on the Fenz-Epstein Modified Anxiety Scale employing items relating to subjective feelings of fear and insecurity, will be used as a measure of general anxiety. Subjects' scores on this scale will be correlated with the amount of autonomic control they attain (as measured by difference between initial baseline and lowest level achieved, and lowest level obtained) in order to ascertain whether this variable contributes to any observed differences in learning.

In addition, all subjects will be administered the Ego Strength Scale from the Minnesota Multiphasic Personality Inventory (MMPI). A series of research studies have shown that individuals who score high on the ego strength scale of the MMPI are more physiologically responsive on a variety of measures (Alexander, Roessler, & Greenfield, 1963; McCollum, Burch, & Roessler, 1969; Roessler, Burch, & Childers, 1966; Roessler & Collins, 1970; Strausbaugh & Roessler, 1970) than subjects with low ego strength scores. Subject's ego strength scores will be correlated with the amount of autonomic control subjects attain in order to ascertain whether this variable is related to the ability to learn autonomic control.

Hypotheses

It is hypothesized that those subjects who report significantly more muscular symptoms in response to stress than autonomic symptoms will learn to decrease their EMG responses better than those individuals who report significantly more autonomic symptoms than muscular symptoms.

The second hypothesis is that those individuals who report significantly more autonomic symptoms in response to stress than muscular symptoms will learn to decrease their GSR responses better than those individuals who report significantly more muscular symptoms than autonomic symptoms.

The third hypothesis is that those individuals who are in the muscular tension group will achieve greater reductions in their EMG levels than in their GSR levels.

The fourth hypothesis is that those individuals who are in the autonomic arousal group will achieve greater reductions in their GSR levels than in their EMG levels.

The fifth hypothesis is that there will be no difference between the muscular tension group and the autonomic arousal group on their ego strength scores on the MMPI.

The sixth hypothesis is that subject's scores on the ego strength scale of the MMPI will correlated positively with their ability to learn to decrease their EMG level, and with their ability to learn to decrease their GSR level.

The seventh hypothesis is that there will be no difference between the muscular tension group and the autonomic arousal group on their anxiety scores on the Fenz-Epstein Modified Activity Scale.

The eighth hypothesis is that subject's scores on the anxiety scale of the Fenz-Epstein Modified Activity Scale will correlate negatively with their ability to learn to decrease their EMG level, and with their ability to learn to decrease their GSR level.

CHAPTER II

METHOD

Subjects

Twenty female subjects were selected from introductory psychology courses on the basis of their scores on the Fenz-Epstein Modified Anxiety Scale. The Anxiety Scale was given to 217 female introductory psychology students. The 10 students who showed the largest difference between the amount of muscular tension symptoms and the amount of autonomic symptoms reported, with the muscular symptoms being higher were chosen to participate in the study. The 10 students who showed the largest difference between the amount of muscular tension and the amount of autonomic symptoms reported, with autonomic symptoms being higher were also chosen to participate.

Instruments

The Fenz-Epstein Modified Anxiety Scale (Fenz & Epstein, 1965) was given to all subjects participating in the experiment. This instrument has three subscales. The first contains items related to symptoms of autonomic arousal. This scale refers to visceral symptoms associated with activation of the autonomic nervous system. Items refer to tachycardia, vasomotor reactions, emotionally induced sweating, failure of body temperature control and digestive disorders. The second subscale relates to symptoms of muscular tension. Items on this scale are descriptive of the effects of sustained contraction of striated or voluntary muscle. Included are items referring to tremor, motor incoordination, backache, neckache, rapid breathing, pressure headaches and skin sensitivity. The third subscale contains items relating to subjective feelings of fear and insecurity. Included are items that refer to the inability to concentrate or relax, the tendency to worry excessively over trifles, unexplained feelings of fear and panic, fitful sleep, compulsive mannerisms and stated feelings of insecurity. (See Appendix B for a complete list of items.)

The scale was given to 52 female and 46 male undergraduates at the University of Massachusetts. Odd-even reliability coefficients were computed independently for each scale, and corrected for attenuation. A reliability coefficient of .83 was obtained for autonomic arousal; .84 for striated muscle tension; and .85 for feelings of anxiety.

All subjects participating in the experiment were given the Ego Strength Scale from the Minnesota Multiphasic Personality Inventory (MMPI). The Ego Strength Scale was derived by Barron (1953). This scale was originally designed to predict the response of psychoneurotic patients to psychotherapy. However, it appears to measure the various aspects of effective personal functioning which are usually subsumed under the term "ego-strength". Among the characteristics which are collectively referred to as ego-strength are physiological stability and good health, a strong sense of reality, feelings of personal adequacy and vitality, permissive morality, lack of ethnic prejudice, emotional outgoingness and spontaneity, and intelligence. This scale consists of 68 items selected from the total MMPI pool of 550 items.

The odd-even reliability of the scale in a clinic population of 126 patients is .76. Test-retest reliability after three months in a sample of 30 cases is .72. (Barron, 1953).

Apparatus

EMG (electromyographic) measures were recorded from an Autogen 1700 Feedback Myograph using standard frontalis placements two inches on either side of center forehead and one inch above each eyebrow (Venables & Martin, 1967). A ground electrode was secured to the forehead midway between the other electrodes. Stereophonic headphones through which the subjects in the experiment received auditory feedback of ongoing muscular tension were connected to the Autogen unit. The feedback was presented in the form of a tone which was logarithmically proportional to the level of EMG activity being monitored.

GSR (galvanic skin response) measures were recorded from an Autogen 3400 Feedback Dermograph. Three silver/silver chloride electrodes were placed on the first three fingertips of the non-dominant hand. The electrodes were kept in place through the use of velcro fasteners. Stereophonic headphones through which the subjects in the experiment received auditory feedback of ongoing skin resistance levels were connected to the unit. The feedback was directly proportional in pitch to skin resistance.

Training for Experimenters

The experimenters were two female graduate psychology students. These students were trained in carrying out the procedures for applying EMG and GSR electrodes, conducting the five EMG and five GSR training sessions, and in giving instructions to the subjects for the Autogen 1700 Electromyograph and for the Autogen 3000 unit. Trainers received practice on mock subjects until they could apply the apparatus for the EMG and GSR accurately, quickly and smoothly. Experimenters observed at least one complete EMG training session and one complete GSR training session by an experienced experimenter. When it was judged that the novice experimenter understood each aspect of both types of training, she was then allowed to conduct a session of EMG training and of GSR training under the observation of an experienced experimenter. When the observer judged the novice experimenter competent in all phases of the sessions, the novice trainer was then allowed to conduct further sessions without supervision.

Procedure

Phase I

In the first phase of the study, potential subjects were asked in their introductory psychology classes to fill out the Fenz-Epstein Modified Anxiety Scale. The scale was filled out by a total of 217 female introductory psychology students. The 10 students reporting the largest difference between autonomic and muscular symptoms, with muscular symptoms being higher were chosen for the muscle tension group. The 10 subects reporting the largest difference between autonomic and muscular symptoms with autonomic symptoms being higher were chosen for the autonomic group. The mean difference between the autonomic and muscle tension scores for the muscle tension group was -.59, as compared to -.25 in the Brandt and Fenz study, and -.21 for the female muscle tension group in the Horwath and Fenz study. The mean difference between the autonomic and muscle tension scores for the autonomic group was +.85, as compared to +.52 in the Brandt and Fenz study, and +.42 for the female muscle tension group in the Horwath and Fenz study.

Phase II

During this phase, all subjects received five one-half hour EMG training sessions and five one-half hour GSR training sessions. Order of training was counterbalanced, with half of each group receiving EMG training first and the remaining half receiving GSR training first, so as to control for possible transfer of training effects. Subjects were randomly assigned within their group to the EMG-GSR or GSR-EMG sequences. At the beginning of their first EMG or GSR training session subjects were asked to complete the Ego Strength Scale taken from the MMPI. During the first EMG training session, subjects were seated in a comfortable chair and asked to sit relaxed with both legs and arms uncrossed. EMG electrodes were attached at the standard frontalis placements. Subjects were instructed to sit quietly while a baseline (in average integral microvolts) was recorded for a three minute period. The earphones were then placed on the subjects head after the following information was given:

> The purpose of this session is to help you learn how to relax by using biofeedback; you will hear a tone through these headphones. Your task will be to reduce the pitch of the tone. As you reduce the pitch, you are actually reducing the level of tension in your forehead muscle. I will know how relaxed you are by monitoring the forehead muscle also. The session will last 21 minutes. Remember to keep your eyes closed and do not talk or move during the session.

Performance with feedback was monitored at three minute intervals by recording average integral microvolts. Subjects were encouraged to keep the feedback tone as low in pitch as possible during the five training sessions.

During the first GSR training session, subjects were seated in a comfortable chair and asked to sit relaxed with both legs and arms uncrossed. Three silver-silver chloride electrodes were placed on the first three fingers of the nondominant hand, through the use of Velcro fasteners. The ground electrode was placed on the ring finger. Subjects were instructed to sit quietly while a baseline (in ohms resistance) was recorded for three minutes. The earphones were then placed on the subject's head after the following information was given:

> The purpose of this session is to help you learn how to relax by using biofeedback; you will hear a tone through these headphones. Your task will be to reduce the pitch of the tone. As you reduce the pitch, you are actually reducing the level of your galvanic skin response. I will know how relaxed you are by monitoring your galvanic skin response also. The session will last 21 minutes. Remember to keep your eyes closed and do not talk or move during the session.

Performance was again monitored at three minute intervals, this time by recording average ohms resistance. Subjects were encouraged to keep the feedback tone as low in pitch as possible during the five training sessions.

Phase III

After the subjects had completed all of the training sessions for both EMG and GSR they were debriefed concerning the nature of the experiment. They were provided with information concerning their own performance on the biofeedback tasks and on the Fenz-Epstein or Ego Strength questionnaires if requested. They were also asked about any cognitive strategies they might have employed to help them gain control over their EMG or GSR responses. After the results were analyzed, letters were sent to all participants reporting the findings.

Design

Independent and Classification Measures

The classification variable used in this study was individual differences in physiological responsivity. Specifically, 10 subjects who reported the largest differences between autonomic and muscular tension scores, with autonomic being higher were assigned to the autonomic group. Ten subjects who reported the largest differences between autonomic and muscular tension scores with muscle tension being higher were assigned to the muscle tension group. These subjects were chosen from a population of 217 female introductory psychology students. All subjects received the same treatment: five one-half hour EMG training sessions and five one-half hour GSR training sessions.

There were three independent within subjects variables used in this study: physiological modalities (GSR and EMG); sessions (five); and trials within each session (eight).

Dependent Measures

The two dependent measures used in this study were EMG levels in integral microvolts and GSR levels in ohms resistance. These were both recorded for an initial three minute baseline period, and at three minute intervals during training sessions. The EMG and GSR recordings were transformed into z scores when comparing subjects learning on the two modalities.

CHAPTER III

RESULTS

Introduction

Results will be presented in five separate sections. The first section will examine the comparability of the autonomic and muscle tension groups on initial EMG and GSR baselines, Ego strength and Anxiety. The second section is an analysis of evidence of learning. The third section reports the interrelationships among personality and physiological measures for both groups combined. The fourth section examines the interrelationships among personality and physiological measures separately for the muscle tension and autonomic groups. Differences between the two groups in their interrelationships are examined. In the final section the relationship of subjects cognitive strategies to learning will be examined.

Comparability of the Muscle Tension and Autonomic Groups

To assure that any obtained differences in learning between the Muscle Tension and Autonomic Groups are a result of differences in physiological responsivity and not a confounding variable, a series of t-tests were performed comparing the initial EMG and GSR baselines, and Ego Strength and Anxiety scores obtained by the two groups.

Two separate t-tests examining the difference between the two groups in initial baselines found that they did not differ significantly on initial EMG baselines, t (19) = .777, p = NS, nor on initial GSR baselines, t (19) = .943, p = NS. Thus, any differences in learning between the two groups will not be a reflection of differences in initial baseline values.

A t-test examining the difference between muscularly reactive individuals' and autonomically reactive individuals' anxiety scores on the Fenz-Epstein Modified Anxiety Scale indicated that the two groups did not significantly differ on this measure t (19) = 1.18, p = NS. Nor did the Ego Strength scores of the two groups differ significantly, t (19) = .213, p = NS. Actually, when rounded to the nearest whole number, the mean ego strength score for both groups was 38, which corresponds to a t-score of 47 or the 38th percentile for the normal female population (Dahlstrom, Welsh, & Dahlstrom, 1972). Thus any obtained differences in learning between the two groups will not be a reflection of differences in anxiety level or Ego strength.

Evidence of Learning

A mixed ANOVA on Groups (2) x Modality (2) x Sessions (5) x Trials (8) was performed on the treatment data (Table III). The GSR and EMG readings were transformed to z-scores for use in this analysis. The between subjects variable was the autonomic and muscle tension groups, and the within subjects variables were the two treatment modalities, five treatment sessions, and eight trials within each session.

There was no significant main group effect on the treatment data, indicating that neither the muscle tension nor the autonomic group

TABLE I

MEAN ANXIETY AND EGO STRENGTH SCORES FOR THE MUSCLE TENSION AND AUTONOMIC GROUPS, AND CORRESPONDING STANDARD DEVIATIONS AND t-TEST RESULTS

			Group		
			Muscle Tension	Autonomic	t
Personality Measure	Anxiety	M	2.65	2.78	1.18
		SD	.48	.35	
	Ego Strength	M	38.1	37.7	.213
		SD	6.76	5.95	

TABLE II

MEAN EMG AND GSR BASELINES FOR THE MUSCLE TENSION AND AUTONOMIC GROUPS, AND CORRESPONDING STANDARD DEVIATIONS AND t-TEST RESULTS

			Group		
			Muscle Tension	Autonomic	t
Modality	EMG	M	1.69	2.09	.777
		SD	.42	1.57	
	GSR	M	7.0	5.7	.943
		SD	3.67	2.36	

TABLE III

ANALYSIS OF VARIANCE SUMMARY TABLE FOR EFFECTS OF TYPE OF PHYSIOLOGICAL RESPONSIVITY (MUSCULAR VERSUS AUTONOMIC) AND MODALITY OF TRAINING (EMG VERSUS GSR) ON SUBJECTS' PERFORMANCE ON BIOFEEDBACK CONDITIONING

Source	SS	df	MS	F	p
Between Subjects (Ss)					
Group (G)	8.6054	1	8.6054	0.3409	NS
Ss W. Groups	454.3274	18	25.2404		
Within Ss					
Modality (M)	3.0137	1	3.0137	0.1822	NS
G x M	3.9122	1	3.9122	0.2365	NS
M x Ss W. Groups	297.7568	18	16.5420		
Session (X)	13.9448	4	3.4862	2.0120	.25
G x X	8.0426	4	2.0107	1.1604	NS
X x Ss W. Groups	124.7518	72	1.7327		
Trials (T)	17.5185	7	2.5026	3.4918	.01
G x T	1.2217	7	0.1745	0.2435	NS
T x Ss W. Groups	90.3081	126	0.7167		
M x X	12.7715	4	3.1929	1.3536	NS
G x M x X	9.2054	4	2.3014	0.9756	NS
M x X x Ss W. Groups	169.8355	72	2.3588		
M x T	8.5644	7	1.2235	1.9807	.08
G x M x T	4.0748	7	0.5821	0.9424	NS
M x T x Ss W. Groups	77.8312	126	0.6177		
X x T	5.6832	28	0.2030	0.7993	NS
G x X x T	6.3961	28	0.2284	0.8995	NS
X x T x Ss W. Groups	127.9898	504	0.2539		
M x X x T	6.05226	28	0.2162	0.8680	NS
G x M x X x T	8.9323	28	0.3190	1.2811	.25
M x X x T x Ss W. Groups	125.5005	504	0.2490		

differed in their ability to learn the two biofeedback modalities. There was no significant main effect for modality indicating that the level of learning obtained in the two different treatment modalities did not differ.

The fact that the main effect for sessions did not reach significance, $\underline{F}$ $(4,72) = 2.0120$, $p < .25$, indicates that there was apparently minimal lasting learning of control over EMG and GSR responses. The main effect for trials was significant, $\underline{F}$ $(7,126) = 3.4918$, $p < .01$. A test for linear trend on the trial means was significant, $\underline{F}$ $(1,126) = 10.698$, $p < .01$. The trial means are shown in graphic form in Figure 1. Although the quick drop from trial 1 to trial 3 could be indicative of a habituation effect, a continued, although much smaller, drop from trials 3 to 8 would seem to indicate that there was some learning occurring within the sessions.

None of the interaction effects were significant, although the interaction of treatment modality with trials did approach significance, $\underline{F}$ $(7,126) = 1.9807$, $p < .08$. When comparing the separate trial means z scores) for the two modalities, it becomes apparent that the drop in muscle tension level (from a mean of .28 for the first trial to a mean of -.28 for the eighth trial) is much larger than the drop in galvanic skin response (from a mean of .11 for the first trial to a mean of -.01 for the eighth trial). Thus the trial effect is much more pronounced for EMG than it is for GSR.

An analysis of covariance (ANACOVA) employing the same design as the above ANOVA, and using initial baselines (i.e., trial 1, session 1 for both EMG and GSR) as the covariate was performed on the treatment

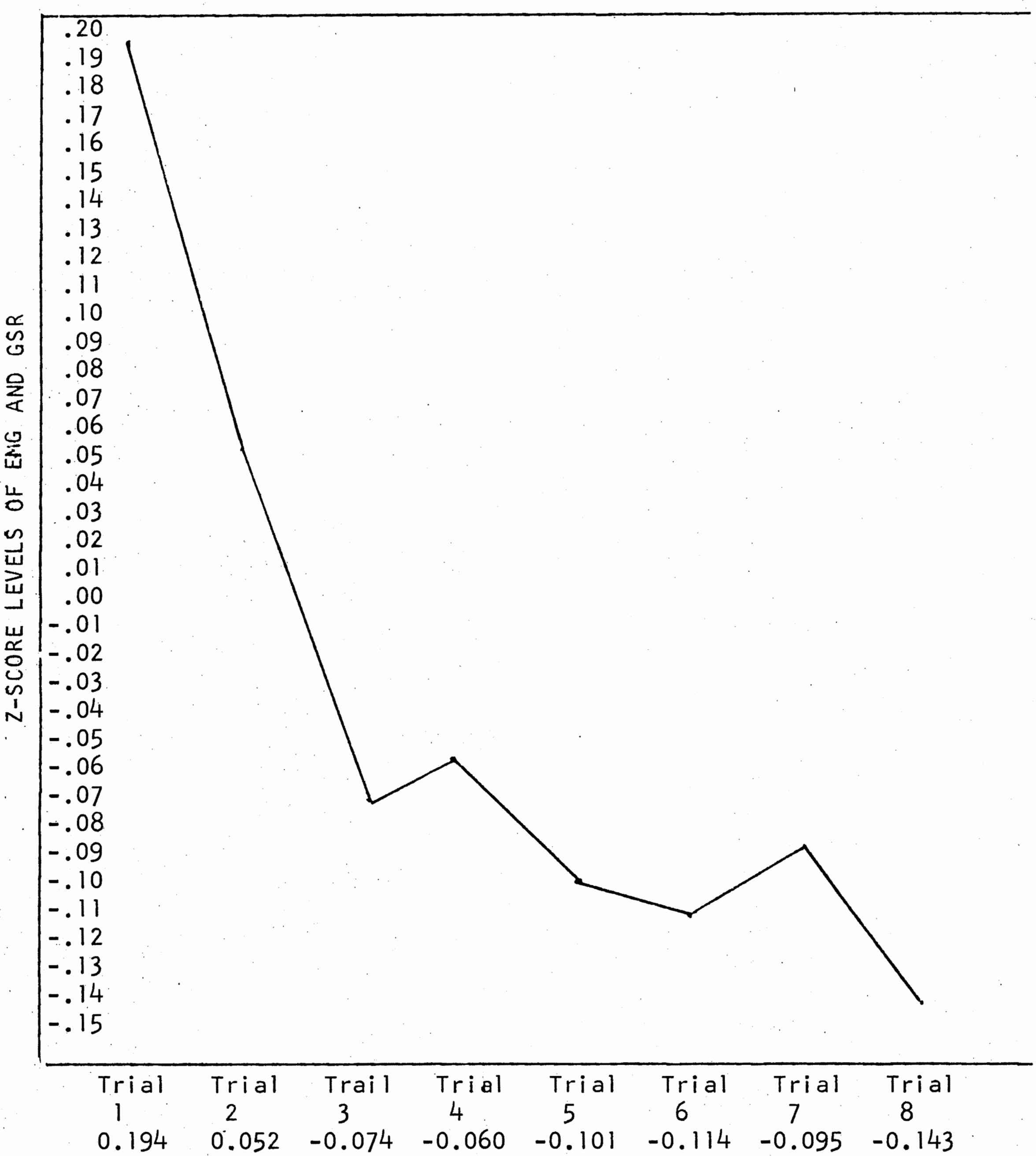

Figure 1. Trial Means For All Training Sessions for All Subjects

data. The data was again transformed into z-scores for use in this analysis. Results of this ANACOVA are presented in Table IV.

TABLE IV

ANALYSIS OF COVARIANCE SUMMARY TABLE FOR EFFECTS OF TYPE OF PHYSIOLOGICAL RESPONSITIVTY AND MODALITY OF TRAINING ON SUBJECTS' BIOFEEDBACK CONDITIONING PERFORMANCE USING THE INITIAL BASELINES AS A COVARIATE

Source	SS	df	MS	F	p
Group (G)	9.3794	1	9.3794	0.7647	NS
Modality (M)	33.5256	1	33.5256	2.7334	.11
G x M	0.3018	1	0.3018	0.0246	NS
1st Covariate	233.3845	1	233.3845	19.0280	.00
Error	429.2861	35	12.2653		
Session (X)	11.9976	4	2.9994	1.5302	.20
X x G	6.8840	4	1.7210	0.8780	NS
X x M	10.4880	4	2.6220	1.3377	NS
X x G x M	8.7815	4	2.1954	1.1200	NS
Error	282.2512	144	1.9601		
Trial (T)	4.6347	6	0.7724	1.7211	.12
T x G	0.8232	6	0.1372	0.3057	NS
T x M	4.9010	6	0.8168	1.8200	.10
T x G x M	2.5373	6	0.4229	0.9442	NS
Error	96.9439	216	0.4488		
X x T	5.1728	24	0.2155	0.8457	NS
X x T x G	5.2133	24	0.2172	0.8523	NS
X x T x M	5.6423	24	0.2351	0.9224	NS
X x T x G x M	7.5560	24	0.3148	1.2353	
Error	220.2043	864	0.2549		

Results of the ANACOVA indicate no significant main nor interaction effects. With initial baselines as a covariate, the trials effect is no longer significant, F (6,126) = 1.72, $p < .12$. This is probably due to the fact that the initial drop from trial 1 (or baseline) to trial 2 was the largest (.14) and this drop is not taken into account in the ANACOVA. The covariate accounted for a significant amount of the variance in the EMG and GSR recordings, F (1,35) = 19.028, $p < .0001$. Thus, it would seem that baselines were predictive of the amount of learning achieved whereas type of physiological responsivity was not.

Considering the two analyses together, there is only minimal evidence of learning. No significant sessions effects were obtained in either analysis. Although a trial effect was found using the ANOVA, when the initial drop from trial 1 to trial 2 which could easily be due to habituation was not considered in the ANACOVA, the trials effect was no longer significant. In addition, what learning did take place does not appear to be related to physiological responsivity. Instead, initial baselines appear to be highly predictive of the levels of learning achieved.

Interrelationships Among Personality and Physiological Measures for Both Groups Combined

A nine x nine matrix of Pearson product moment correlations (Appendix E) on the Fenz-Esptein Physiological Reactivity Score, the Fenz-Epstein Anxiety Score, Ego Strength, initial GSR baseline, initial EMG baseline, difference between GSR baseline and the lowest GSR level reached, difference between EMG baseline and the lowest EMG level reached, lowest GSR level reached and lowest EMG level reached, was computed for both the Autonomic and Muscle Tension Groups combined.

Two out of the 36 correlations would be expected to be significant at the .05 level by chance alone. The Fenz-Epstein Physiological Reactivity Score was not significantly related to any of the other measures. The Fenz-Epstein Anxiety Score correlated significantly with the inital EMG baseline $r\ (20) = +.44$, $p < .03$ and the lowest EMG level reached $r\ (20) = +.47$, $p < .02$. The Ego Strength score did not correlate significantly with any of the other measures. GSR baseline correlated highly with both the obtained GSR difference $r\ (20) = +.89$, $p < .001$ and the lowest GSR level reached $r\ (20) = +.70$, $p < .001$. EMG initial baseline also correlated highly with the EMG difference obtained. $r\ (20) = +.97$, $p < .001$. The GSR difference and EMG difference obtained were significantly correlated, $r\ (20) = +.38$, $p < .05$.

The correlation results were in agreement with the previously reported ANACOVA, in that they showed initial baselines to be highly correlated with various measures of learning. It was shown that the higher an individual's initial GSR baseline, the larger the obtained difference between the initial baseline and the lowest level reached. Also, the lower your initial GSR baseline, the lower the lowest level of GSR reached. The higher the initial EMG baselines, the larger the difference achieved between initial baseline and the lowest level reached. In addition, anxiety apparently is related to EMG baselines; the more anxious an individual is the higher their EMG baseline.

Differences Between the Autonomic and Muscle Tension Groups in Their Interrelationships Among Personality and Physiological Measures

The nine x nine matrix of Pearson product moment correlations described above was again computed, this time separately for the autonomic and muscle tension groups (Appendix F). This yielded matrices of 36 values each; two values are expected by chance alone to be significant at the .05 level. The correlation matrix for the muscle tension group yielded ten significant r's. The Fenz-Epstein Physiological Reactivity Score was negatively correlated with the Anxiety score, $r\ (10) = -.65$, $p < .02$. It should be noted that the more muscularly reactive an individual in the muscle tension group, the more negative their physiological reactivity score. Therefore, the more muscularly reactive an individual was, the more anxious she was. Anxiety was also negatively correlated with the EMG obtained difference, $R\ (10) = -.54$, $p < .05$. The Fenz-Epstein Physiological Reactivity Score was positively correlated with Ego Strength, $r\ (10) = +.57$, $p < .04$. The more muscularly reactive an individual was, the less Ego strength she had. Ego strength was also positively correlated with initial GSR baseline, $r(10) = +.55$, $p < .05$. Ego strength was positively correlated with both the GSR obtained difference, $r\ (10) = +.67$, $p < .02$, and the EMG obtained difference, $r\ (10) = +.65$, $p < .02$. GSR initial baseline was highly correlated with the achieved GSR difference, $r\ (10) = +.89$, $p\ \ .001$, as was the EMG baseline with the achieved EMG difference, $r\ (10) = .82$, $p < .002$. In addition, the initial GSR baseline was correlated with the lowest level of GSR reached, $r\ (10) = .69$, $p < .01$.

The correlation matrix for the autonomic group resulted in 13 significant r's (Appendix G). The Fenz-Epstein Physiological Reactivity Score correlated positively with both the lowest GSR level achieved, $r\ (10) = +.62,\ p < .03$, and the lowest EMG level achieved, $r\ (10) = +.72,\ p < .01$. The more autonomically reactive an individual was the higher the lowest levels of EMG and GSR she reached. The Fenz-Epstein Anxiety Score highly correlated with several physiological measures for the autonomic group. The anxiety score was correlated with both the GSR initial baseline, $r\ (10) = +.81,\ p < .002$, and the EMG initial baseline, $r\ (10) = +.80,\ p < .003$, for the autonomic group. The anxiety score was also highly correlated with both the obtained GSR difference, $r\ (10) = +.76,\ p < .005$, and the obtained EMG difference, $r\ (10) = +.77$, $p < .004$. The more anxious an autonomically reactive individual was, the higher her GSR and EMG baselines, and the larger her achieved GSR and EMG differences. Ego strength was negatively correlated with both the GSR initial baseline, $r\,(10) = -.55,\ p < .05$, and the GSR obtained difference, $r\ (10) = -.57,\ p < .05$. For the autonomic group, initial baselines were highly correlated with achieved differences; the correlation between initial GSR baseline and achieved GSR difference being $r\ (10) = +.87,\ p < .001$, and the correlation between initial EMG baseline and achieved EMG difference being $r\ (10) = +.89,\ p < .001$. In addition, the initial GSR baseline was significantly correlated with the lowest level of GSR reached, $r\ (10) = +.68,\ p < .02$. The initial EMG baseline correlated with the obtained GSR difference, $r\ (10) = +.62$, $p < .03$. Finally for the autonomic group the obtained GSR difference was correlated with the obtained EMG difference, $r\ (10) = +.66,\ p < .02$.

It should be noted that even though all significant correlations have been reported in the preceeding paragraphs, only the strongest of these will be considered in the following discussion.

The correlations of the two groups were similar on the following pairs of variables: EMG baseline and EMG difference, GSR baseline and GSR difference, GSR baseline and lowest GSR level. They differed in that, for the muscle tension group, physiological reactivity was correlated with both anxiety and ego strength, whereas physiological reactivity was not correlated with either of these personality measures for the autonomic group. For the autonomic group, physiological reactivity correlated with both the lowest EMG and lowest GSR level achieved. However, for the Muscle Tension group, physiological reactivity was not correlated with any physiological measure. For the Autonomic group, anxiety was correlated with a number of physiological measures: EMG baseline, obtained EMG difference, GSR baseline, and obtained GSR difference, whereas the only physiological measure that anxiety correlated with for the muscle tension group was the lowest level of EMG achieved. For the Muscle Tension group, ego strength was correlated with both the EMG and GSR difference, whereas ego strength did not correlate with any other variable for the autonomic group. For the autonomic group the GSR difference was correlated with both the EMG baseline and the obtained EMG difference, whereas for the Muscle Tension group none of the GSR measures were correlated with any of the EMG measures. Figure 2 shows these relationships for both the Muscle Tension and the Autonomic groups.

The above correlations were transformed to Fisher z-scores and z-tests for significant differences between the autonomic and muscle tension groups were performed. The two groups showed significantly

MUSCLE TENSION GROUP AUTONOMIC GROUP

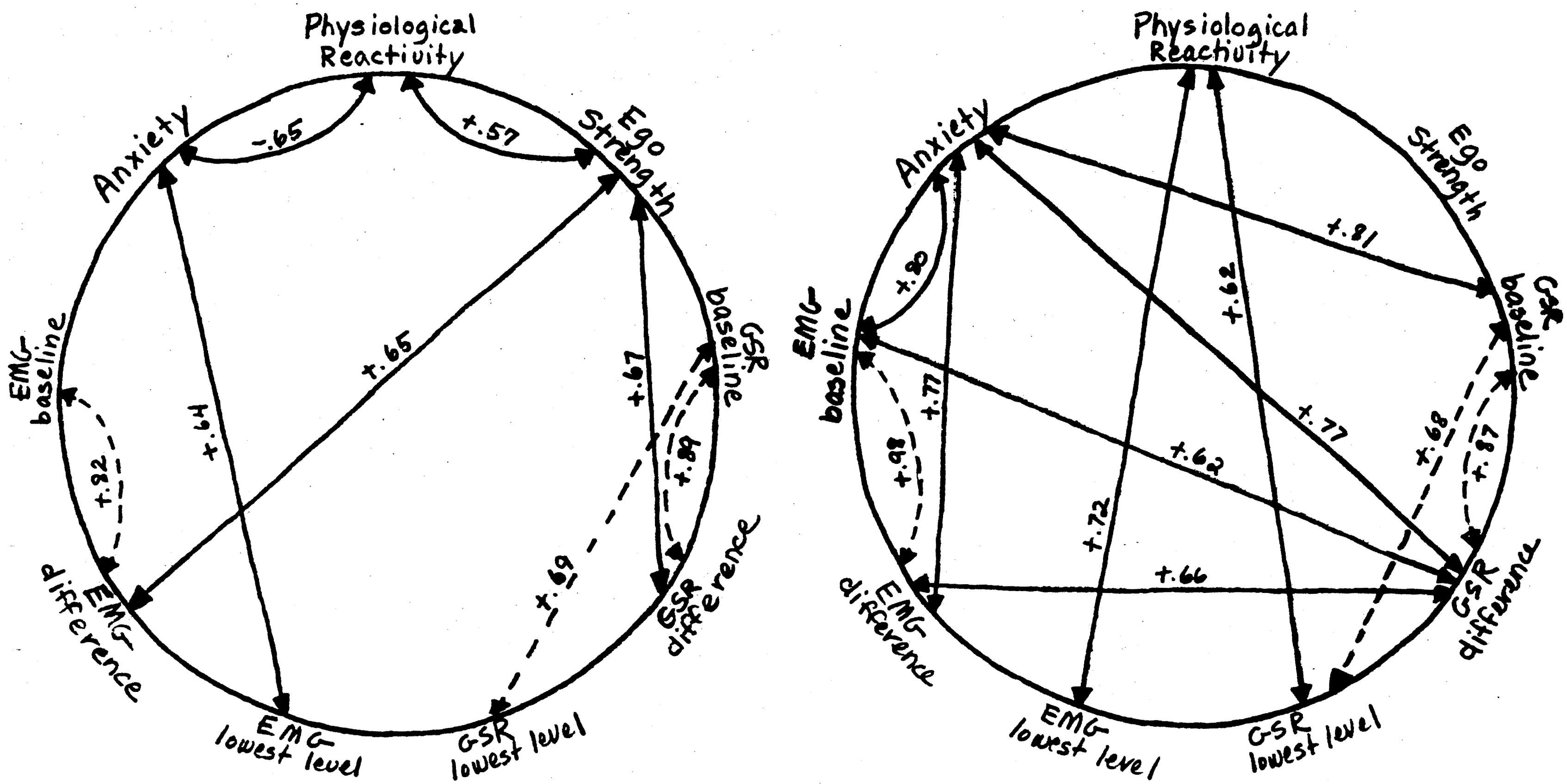

Figure 2. The Interrelationships Among Personality and Physiological Measures for the Muscle Tension Group and Autonomic Group. (Dotted lines indicate that the correlations for that pair of variables was significant for both groups.)

different relationships (at the .01 level of probability) on the following pairs of variables: physiological reactivity and the lowest EMG level obtained ($z = 2.73$, $p < .01$, two tailed), anxiety and EMG obtained difference ($z = 3.04$, $p < .01$, two tailed), and Ego strength and GSR difference, GSR difference ($z = 2.73$, $p < .01$, two tailed).

To explain the first of the above significant z-tests on these transformed coefficients the two groups' correlation will be contrasted. For the Muscle Tension group, there was a -.50 correlation between the Fenz-Epstein Physiological Reactivity score and the lowest EMG level achieved. Since the more muscularly reactive an individual in the Muscle Tension group is the more negative their physiological reactivity score, this correlation indicates that the less muscularly reactive an individual, the lower the lowest achieved EMG level. The Autonomic group obtained a = +.72 correlation between their physiological reactivity score and their lowest EMG level. Thus, the less autonomically reactive an individual in the autonomic group, the lower their lowest EMG level. Therefore, the more physiologically reactive in either direction a subject was, the less evidence of EMG learning.

In regard to the second significant z-test, for the Muscle Tension group, anxiety was negatively correlated (-.54) with the obtained EMG difference; the less anxious an individual in this group was, the greater the difference in EMG level from initial baselines. For the autonomic group, anxiety was positively correlated (+.77) with the EMG difference; the more anxious an individual in this group, the greater the difference in EMG levels from initial baselines.

Finally, for the third significant z-test, for the Muscle Tension group, ego strength was positively correlated with the obtained GSR difference (+.67); the higher the ego strength score for an individual in this group, the larger the obtained GSR difference. Whereas, for the Autonomic group, ego strength was negatively co-related (-.57) with the obtained GSR differences; the less ego strength for an individual in this group, the larger the obtained GSR difference.

The Relationship Between Cognitive Strategies and Learning

The strategies employed by subjects to lower their EMG and GSR that were most often mentioned were to think pleasant or relaxing thoughts or imagine oneself in a pleasant situation, clearing the mind of all thoughts, concentrating on a single image or word and trying to relax various parts of the body. There was no clearcut relationship between any of the strategies employed and the ability to learn biofeedback control.

CHAPTER IV

DISCUSSION

The major focus of this study was the effect of physiological reactivity on the ability to learn biofeedback. More specifically, it was hypothesized that individuals who are more physiologically reactive in one modality would be able to learn to control that modality more readily than individuals who are reactive in a different modality. In addition, it was hypothesized that an individual would more readily learn to control that particular modality in which she is most physiologically reactive than one in which she is not. The two types of physiological reactivity used in the study were muscular and autonomic. Individuals in these two groups were found to be equivalent in levels of anxiety, ego strength, and initial EMG and GSR baselines. Thus, the two groups did not appear to differ significantly on any variable except physiological reactivity. The two training modalities employed were EMG and GSR. Results of the data analysis indicate that biofeedback learning was relatively unaffected by the individual's type of physiological reactivity, the type of modality to be trained, or an interaction of the two. Thus, individuals do not appear to learn to control that modality in which they are most physiologically reactive more readily than another modality, nor do they learn to control that modality more readily than another group of individuals who are more physiologically reactive in a different modality.

One factor that may have made it difficult to differentiate between the two groups in learning is that there was actually very little evidence that any learning took place. There was no significant sessions effect and the obtained significant trials effect could easily be a result of habituation. The modality by trials interaction approached significance ($p < .08$). An examination of the trial means revealed that the trial effect is much more pronounced for EMG than it is for GSR. When examining the session means for EMG trials, there is a steady, but insignificant, drop until the last session, in which there is a sharp rise (session 1 = .08, session 2 = -.11, session 3 = -.15, session 4 = -.26, session 5 = .01). For GSR, the decline lasts only the first two sessions, and gradually rises until it reaches a high at the fifth session (session 1 = -.06, session 2 = -.21, session 3 = -.01, session 4 = .07, session 5 = .20). The above session means are means of the transformed z-scores. So again, the sessions means give some indication of EMG learning, but no indication of any GSR learning.

Parodoxically, when asked in a questionnaire after the treatment which modality they thought was easier to learn, 10 of those 15 who returned their questionnaires said that they thought GSR was easier to learn to control. Asked which they thought was the most relaxing, 11 out of 15 answered GSR. While observing the subjects during the treatment sessions, it was noted that over three-fourths of them went to sleep at some time during the GSR training, and several individuals went to sleep during every GSR session. Going to sleep did not appear to be related to reaching any particular level of GSR. For example, one subject went to sleep when she reached a GSR of 4.8 micromhos in one session, and when she reached a GSR of 9.0 micromhos in another session.

Nor did sleeping seem to be related to the amount of drop in GSR level. For example, one subject went to sleep after dropping 3.6 micromhos from her starting baseline, another after no drop from baseline, and a third after a 5.7 micromhos jump from starting baseline. Once asleep, individuals varied in their galvanic skin response. Some stayed at the same level that they went to sleep at, some continued to drop while sleeping, and still others experienced a rise in their GSR while sleeping. Time of training did not appear to relate to sleeping either; some individuals fell asleep after six minutes, others after 12, still others after 15 and 18. One possible explanation for the large number of subjects going to sleep during GSR training may involve the tone used for feedback. Several of the subjects spontaneously commented on its relaxing nature, saying that they much preferred it to the tone emitted from the Autogen 1700 Feedback Myograph. Since sleeping definitely appeared to interfere with learning control of GSR, one might consider using some different, less relaxing form of feedback such as clicks in future GSR training.

Another factor that appeared to contribute to lack of treatment effects for GSR was the considerable variability from session to session for starting baselines. For example, the starting baselines for one subject for the five sessions were: session 1 = 6.9 micromhos, session 2 = 4.8 micromhos, session 3 = 5.1 micromhos, session 4 = 9.6 micromhos and session 5 = 11.4 micromhos. This amount of variation was typical of most subjects. It is unknown why the baselines varied so much. The galvanic skin response is known to be affected by temperature, and since the room temperature varied considerably throughout the study (from 64 to 82) it was thought that the variation in room temperature may have been responsible for the variations in starting GSR baselines. However, a correlation performed between room temperatures and starting baselines was nonsignificant. This could either mean that there was no relationship between temperature and GSR baselines or it could mean that temperature affected individual subjects' baselines differently as did sleep. Significant, although low correlations have been found between the Galvanic Skin Response and a number of other environmental factors such as pressure, humidity, and air contamination (Brown, 1967). Unfortunately no record of these variables is available in the present study. It is recommended that future studies utilizing GSR conditioning make every effort to control and monitor the above mentioned environmental factors.

The lack of conditioning effects for EMG is less easily explained. Other studies have obtained significant effects using the same number and length of sessions. For example, a study run several weeks prior to this study, in the same room, using the same equipment, the equivalent of six sessions of the same length as the present study, and female subjects taken from the same introductory psychology classes, obtained both a significant sessions and trials effect (Maly, 1977). A possible explanation for this lack of conditioning can be derived by examining the relationship between the Fenz-Epstein Physiological Reactivity score and the lowest EMG level achieved. For the Muscle Tension group, the less muscularly reactive an individual was, the lower the lowest EMG level she obtained. For the autonomic group, the less autonomically reactive an individual, the lower the lowest EMG level she obtained. In other words, the more extreme one was on this measure (either more muscularly reactive or more autonomically reactive) the poorer one did on this measure of EMG learning. It may be that being extremely physiologically reactive in either direction is a hindrance to learning control of biofeedback, and that those individuals who are moderately reactive may be the best biofeedback conditioners. If this is the case, the lack of learning in the present study may have been due to the extreme physiological reactivity of the subjects.

The preceding discussion on the relationship of physiological reactivity to biofeedback conditioning calls to mind the studies concerned with the relationship of autonomic perception to autonomic control (Greene & Nielson, 1966; Blanchard, Young, & Macleod, 1972; Whitehead, Drescher, & Blackwell, 1976) in which individuals with low autonomic perception learned autonomic control more readily than individuals with high autonomic perception; and the study by Bergman and Johnson (1971) which found that individuals with middle autonomic perception scores displayed more heart rate control than those subjects with high or low scores. The hypothesis advanced in explanation of these results was that high autonomic perceivers have been shown to overestimate their autonomic activity, so that low or middle autonomic perception scorers may actually be more accurate in their perception of their autonomic activity. In light of the above findings, an alternative hypothesis might be that individuals who are highly physiologically reactive are also more aware of their autonomic activity since, in fact, they have more to be aware of. Therefore, it may be increased physiological reactivity rather than increased autonomic awareness which hinders the performance of individuals with high autonomic perception.

Although lack of conditioning may have been one factor that made it difficult to distinguish between the two groups in learning, the relationship between baselines and learning may have been much more important in contributing to the lack of differences in learning found between the two groups. The initial baselines (trial 1, session 1) were highly correlated with both the achieved difference ($r = +.89$) and lowest level achieved ($r = +.70$) for GSR, and with the achieved difference of EMG ($r = +.97$). In addition, the ANACOVA using initial baselines as a covariate, found that they accounted for a significant amount of the variation in EMG and GSR scores. Thus, it appears that initial baselines are a highly potent predictor of learning. Since the two groups did not differ significantly in their initial baselines, and since initial baselines do appear to be significantly related to learning, it is not surprising that no differences were found between the two groups in the amount of biofeedback control achieved. It is interesting to note that the lowest EMG level achieved was not highly correlated with the EMG baseline ($r = .25$), nor was the correlation of the GSR baseline with the lowest GSR level achieved as high as that for GSR baseline and GSR difference. Therefore, if one wants a measure of learning that is relatively free from the influence of initial baselines, the lowest level achieved appears to be the best choice.

Although the lowest EMG level achieved was not significantly related to initial EMG baseline, it was significantly related to the anxiety level of the individual as measured by the third subscale of the Fenz-Epstein Modified Anxiety Scale ($r = .47$, $p < .02$). The correlations of anxiety with the two other measures of learning approached significance: anxiety with EMG difference ($r = .32$, $p < .08$) and anxiety with the lowest level of GSR achieved ($r = .35$, $p < .07$). So, in addition, to initial baselines, anxiety also appears to be related to levels of learning achieved. Since the two groups were equivalent on this measure also, this relationship can be added to the list of factors contributing to no differences in learning between the two groups.

Although there were many similarities between the two groups that apparently contributed to the lack of differences found in their biofeedback learning, an examination of the separate correlation matrices calculated for each group reveals some significant differences in the way the various personality and physiological measures interrelated for the two groups. Although z-tests indicated that there were three sets of correlations that were significantly different, only two of these pointed to actual differences between the two groups. The third set of correlations, those between physiological reactivity and the lowest EMG level obtained, were found to be significantly different for the two groups because the more muscularly reactive an individual was in the muscle tension group, the more negative her Fenz-Epstein physiological reactivity score became, whereas the more autonomically reactive an individual in the autonomic group, the more positive her Fenz-Epstein physiological reactivity score became. Thus, when the lowest EMG level obtained was positively correlated with the Fenz-Epstein physiological reactivity score for the autonomic group, and negatively correlated with the physiological reactivity score for the muscle tension group, the same relationship was being described for both groups; that is, the more physiologically reactive an individual was in either direction, the higher her lowest obtained EMG level.

The two remaining sets of correlations that were found to be significantly different for the two groups appear to be related. The first of these two sets involved the correlations between anxiety and the obtained EMG difference. For the muscle tension group, the less anxious an individual, the greater the difference in EMG level from initial baselines, whereas for the autonomic group, the more anxious an individual, the greater the difference in EMG levels from initial baselines. These differing correlations of anxiety with obtained EMG differences, can be traced to the difference between the two groups in their relationships of anxiety to initial baselines. For the autonomic group, anxiety is strongly related to both the EMG baseline ($r = +.80$, $p < .002$) and the GSR baseline ($r = +.81$, $p < .002$), whereas anxiety and baselines do not appear to be related for the muscle tension group: GSR baseline and anxiety ($r = +.11$, $p < .38$) and EMG baseline and anxiety ($r = -.20$, $p < .29$). The difference between the correlations of anxiety with EMG baseline for the two groups was actually significant at the $p < .05$ level, but was not reported as the required probability level chosen was $p < .01$. Even though the difference between the two groups in the way anxiety related to the obtained EMG difference reached a higher level of significance than the difference between the two groups in the way anxiety related to EMG baseline, considering the extremely high correlations between baselines and obtained differences, it is likely that the relationship of anxiety with the EMG difference was mediated by the relationship of anxiety and initial EMG baseline.

The second of the two sets of correlations that were found to be significantly different for the two groups involved ego strength and GSR difference. For the autonomic group, the less ego strength, the greater the difference achieved from the initial GSR baseline. For the muscle tension group, the more ego strength the greater the difference achieved from the initial GSR baseline. Again this difference can be traced to a difference between the two groups in the way ego strength is related to initial baselines. For the muscle tension group, ego strength was positively correlated with initial GSR baseline ($r = +.55$, $p < .05$); i.e., the higher one's ego strength in the muscle tension group, the higher their initial GSR baseline. For the autonomic group, ego strength was negatively correlated with the initial GSR baseline ($r = -.55$, $p < .05$), i.e., in the autonomic group the higher one's ego strength, the lower their initial baseline.

Considering these above mentioned differences together, it would seem that the most notable difference between the two groups is the different ways in which the personality variables, ego strength and anxiety, relate to their initial baselines. It should be noted that anxiety and ego strength are negatively correlated for both groups combined ($r = -.35$, $p < .07$). For the autonomic group, the relationship is congruent with what one might expect: the lower the ego strength or the higher the anxiety, the higher the initial baseline (with the exception of ego strength and EMG baseline which were not significantly correlated). One would expect that higher levels of anxiety or lower levels of ego strength would be reflected in higher levels of muscle tension and in higher levels of galvanic skin response. However, for the muscle tension group, there is no relationship between anxiety and initial baselines, and the relationship between ego strength and initial baselines is the opposite of what one might expect: the higher the ego strength of the individual, the higher both the EMG and GSR initial baselines. Thus, for the muscle tension group, higher levels of anxiety and lower levels of ego strength are not reflected in corresponding higher EMG and GSR baselines.

A possible explanation for this unexpected relationship between ego strength and initial baselines for the muscle tension group is obtained by an examination of the work by Seymour Fisher and Sidney Cleveland on body boundaries (Fisher & Cleveland, 1968; Fisher, 1970). Fisher and Cleveland were able to differentiate individuals into either a high barrier or low barrier category on the basis of their responses to the Rorshach. Those individuals who fall into the high barrier category view their body as clearly and sharply bounded, with a high degree of differentiation from nonself objects. Those individuals who fall into the low barrier category regard their body as lacking demarcation or differentiation from nonself objects.

Fisher and Cleveland found clear differences in the patterns of physiological reactivity exhibited by the two groups. They found that individuals with definite boundaries tend to manifest relatively high responsivity in the outer body layers and relatively low responsivity in the body interior. A converse pattern was found to characterize individuals with indefinite boundaries. Incidentally, Fisher and Cleveland considered GSR to be an external response or a response associated with outer body layers. Drawing upon some differences in personality characteristics found between the two groups, Fisher and Cleveland (1968) offer the following explanation for the differences in physiological reactivity found between the two groups:

> High barrier persons grow up in a setting in which, active, voluntary, reality-coping attitudes are emphasized. Such attitudes are relatively less emphasized in the families of low Barrier persons. Further, the exterior layers of the body (particularly the musculature) tend to be equated with

> voluntary, reality-coping behavior, whereas the body interior is equated with involuntary response. The orientation of the high Barrier person is therefore translated into a persistently high level of activation of the exterior body layers. There is a set to respond with this region of the body which is manifested in a long term pattern of preparatory excitation. The less aspiring, less active orientation of low Barrier persons results in a relatively low level of preparatory excitation in the exterior body layers and permits a high degree of excitation of the body interior (p. 358).

A comparison of the autonomic group with either the high or low barrier group cannot be made since the autonomic individuals were highly reactive on physiological responses that would be considered to be external according to Fisher and Cleveland's schemata, in addition to internal physiological responses. However, the muscularly reactive individuals in the present study are comparable to the high barrier persons described by Fisher and Cleveland in that both groups are considerably more physiologically reactive externally than they are internally. Fisher and Cleveland see the high level of activation of the exterior body layers of the high barrier individual to be a result not of anxiety, but instead as a translation of the active, voluntary, reality-coping orientation of these individuals. Perhaps the same sort of relationship is operating for the muscularly reactive individuals in the present study. The higher their ego strength (which would seem to correspond to the active, voluntary, reality-coping orientation that Fisher and Cleveland describe), the higher the level of activation in their body exterior, i.e., the higher their initial EMG and GSR baselines.

In conclusion, the present study was an attempt to discover if being physiologically reactive in a specific modality facilitated biofeedback learning in that modality. Results showed that being physiologically reactive in a particular modality did not enhance learning in that modality. Instead, this study found that initial baselines seemed to be most predictive of learning and initial baselines do not appear to be related to physiological reactivity.

There was only minimal evidence of any learning of control over GSR. This was attributed to the interference of sleep with learning, and the variability of starting baselines from session to session. Although there was more evidence of EMG learning, a significant sessions effect was not obtained as in previous studies employing the same length of treatment. It was postulated that the extreme reactivity of the subjects used in the present study may have hindered their performance on the biofeedback tasks, and that individuals who are moderate or low in physiological reactivity may be the best conditioners.

The most notable difference found between the two types of physiologically reactive individuals was in the way the personality variables related to their initial baselines. For the autonomic group the relationship was congruent with what one might expect: the more anxious, and the less ego strength an individual had, the higher her EMG and GSR baselines. However, for the muscle tension group there was no relationship between anxiety and initial baselines, and the higher the ego strength for a muscularly reactive individual, the higher her EMG and GSR baselines. Drawing upon the body boundary work of Fisher and Cleveland, it was hypothesized that this relationship between ego strength and EMG and GSR baselines for the muscle tension group was a translation of the muscularly reactive individual's active, voluntary, reality-coping orientation into activation of the body exterior.

The results of the present study have implications for future research on individual differences in physiological reactivity and the ability to learn biofeedback control. Results of this study point to the possibility that the degree of physiological reactivity (i.e., low, moderate, extreme) may be more important than the type of physiological reactivity in determining ability to learn biofeedback control. A follow up study that included groups of low, moderate, and extreme physiologically reactive individuals could determine the relationship, if any, between degree of physiological reactivity and the ability to learn biofeedback control.

On a more general level, results of the present study indicate that caution is needed when the results of biofeedback studies using normal subjects are applied to the clinical setting. The type of individual who is apt to seek out biofeedback training in the clinical setting, may be different from the normal subject generally used in biofeedback studies in a variety of characteristics that will seriously alter his/her biofeedback performance. For example, the present study indicated that individuals who are extremely reactive may need more sessions than normal individuals before a treatment effect becomes evident.

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APPENDIXES

APPENDIX A

LITERATURE REVIEW

A Literature Review of Studies Investigating the Relationship Between Personality Variables and the Ability to Learn Autonomic Control

The personality variable most widely studied in relation to ease of learning autonomic control is that of locus of control. Individuals are said to have an internal locus of control if they usually appraise reinforcements to be contingent upon their own actions and hence under their own control. External locus of control individuals usually appraise reinforcements to be beyond personal control or not contingent upon their actions. The majority of studies using several different feedback modalities (HR, GSR, EMG and EEG) have found that in general those subjects with an internal locus of control are better able to learn autonomic control than those subjects with an external locus of control. In the area of electromyograph (EMG) conditioning, Fotopoulos and Binegar (1976), using 24 internal and 24 external males as determined by their scores on the Rotter Internal/External Lows of Control Scale, found that internal controllers were able to exert a significantly greater degree of control over both EMG and EEG activity than were external controllers. This difference was not found for control over skin temperature. Reinking, Morgret and Tamayo (1976) found that internal subjects (indicated by scores on Rotter's IE scale) lowered their EMG levels significantly more than external subjects. In another study, done with 57 female subjects, initial baselines and change in frontalis EMG were compared for internal and external subjects across three treatment modalities: biofeedback, relaxation training and control. Before training, frontalis EMG levels of externals exceeded those of internals and both training groups were elevated compared to controls. Internals in both training procedures decreased frontalis EMG over trials while only externals in progressive relaxation did so. Neither externals in the biofeedback condition nor in the control group significantly decreased their frontalis EMG levels. Only internals in the training conditions were able to maintain frontalis EMG levels significantly lower than baselines after treatment (Jordan & Schallow, 1975). In contrast to the above studies, Phillips (1976) using 64 female subjects found that locus of control orientations did not effect responsiveness to EMG biofeedback training.

In regards to alpha EEG conditioning, Johnson and Meyer (1974) found that of their 24 female subjects those with an internal locus of control were better able to use feedback to increase alpha activity than those subjects with an external locus of control. Another study (Goesling, May, Lavond, Barnes, & Carreira, 1974) using 15 externally oriented subjects and 15 internally oriented subjects as determined by the Locus of Control Scale, found that both groups were equally successful in increasing the density of alpha waves, however, internally oriented subjects were better able to enhance their alpha wave production (frequency) than were externally oriented subjects. A study by Grauke (1974) obtained results that conflicted with the above two studies. He compared the pre-training and post-training percentage of alpha rhythms of internalizers and externalizers. He found that those subjects on the extremes of the locus of control dimension took longer to achieve criterion levels of alpha percent. Those subjects with a more external locus of control had more percent alpha on the last session and less learning variability than those subjects with a more internal locus of control.

In a study looking at the effects of locus of control on ability to lower the galvanic skin response (GSR) it was found that those subjects who were best able to lower their GSR's had significantly higher internal control scores than those who could not make use of biofeedback (Wagner, Bourgeus, Levenson, & Denton, 1974).

A couple of studies have been done on the relationship between locus of control and heart rate conditioning. A study by Ray and Strupp (1972) using 20 internal and 20 external locus of control subjects found that across all trials, the internal locus of control subjects were better able to increase their heart rate as compared with externals, and the external locus of control subjects were better able to decrease their heart rate as compared with internals. A later study by Ray (1974) obtained the same results.

In summary, the majority of studies investigating the relationship of various types of biofeedback training and locus of control, have found internal locus of control individuals are better able to achieve autonomic control than external locus of control subjects. The most notable exception occurs in heart rate conditioning, where external locus of control subjects are better able to decrease their heart rate as compared with internal locus of control subjects.

Another personality variable that has been studied in relation to autonomic conditioning is that of introversion/extraversion. Eysenk hypothesized that introverts are more sensitive and begin to respond at stimulus intensities which are ineffective for extraverts. Therefore, it has been hypothesized that introverts would be more conditionable and would more readily gain control over their autonomic responses than would extraverts. The research evidence thus far does not support this hypothesis, instead there seems to be no difference between introverts and extraverts in their ability to learn autonomic control. A study involving classical conditioning by Morgenson and Martin (1969) looked at the relationship between introversion/extraversion and autonomic conditioning in three response systems: skin resistance, pulse rate and pulse volume. There were no significant correlations between conditioning and the introversion/extraversion dimension (as determined by the Eysenk Personality Inventory). Instead conditioning in this study appeared to be related to awareness of the CS-USC contingency. Subjects were interviewed afterwards to assess whether or not they were aware of this contingency. Most of the subjects (93 out of 115) could verbalize this contingency and evidence of conditioning was clearcut in this group and virtually non-existent in the unaware group.

In a study looking at the relationship between alpha enhancement and introversion/extraversion (Travis, Kondo, & Knott, 1974), no difference was found between introverts and extraverts (N = 45) in their ability to enhance alpha. Another study, this time looking at the ability to increase left forefinger temperature again found no differences between the 18 introverts and 18 extraverts in ability to learn this biofeedback task (Carlton, 1974). Thus, although there are fewer studies done on the relationship between this personality variable and ability to learn autonomic control, the evidence available suggests that introversion/extraversion does not predict success on biofeedback learning tasks.

Two studies have been done investigating possible correlations between field dependence/independence and autonomic control. A field dependent individual tends to experience and process environmental stimuli in a global, undifferentiated manner and to fail to maintain a "separateness" of his/her body from the surrounding field. A field independent individual maintains internalized frames of reference and orientation independent of environmental distractions. Tutone (1974) looked at the relationship of Witkin's dimension of field-dependence to the ability to voluntarily enhance the EEG alpha rhythm. Field dependence was assessed by latencies on the Embedded-figures test. It was found that the percent alpha produced was negatively related to EFT latencies, that is, field independent subjects produced more alpha than field dependent subjects. In contrast, a study by Berger (1974), found that field dependent subjects were better able to control their heart rates in biofeedback tasks involving both acceleration and deceleration of heart rate than were field independent subjects. Thus, the predictive value of field independence/dependence for ability to learn autonomic control remains uncertain at this point. Further research in various biofeedback modalities is needed to delineate the relationship between field dependence/independence and autonomic control.

Several studies have looked at the relationship between autonomic perception and the ability to achieve autonomic control. It was initially thought that individuals high in autonomic perception would best be able to learn control over their autonomic processes. Greene and Nielson (1966) compared high and low autonomic perceivers (as measured by Mandler's Autonomic Perception Questionnaire) on their ability to achieve control of their galvanic skin response. Their data indicated that low autonomic perceivers were more successful than high autonomic perceivers in gaining control. Bergman and Johnson (1971) found that those subjects with middle autonomic perception scores displayed more heart rate control in both directions than subjects high or low in autonomic perception. In another study involving heart rate (Blanchard, Young, & Macleod, 1972) it was found that low autonomic perceivers were able to successfully raise and lower their heart rates using continuous proportional visual feedback, whereas high autonomic perceivers were not able to make significant alterations in heart rates. A study by Whitehead, Drescher and Blackwell (1976) used a more direct measure of the subject's awareness of his/her internal activity. They compared performance in a signal detection task for perception of heart beat with subsequent learning of differential heart rate control. They found that sensitivity for perceiving heart beat was negatively correlated with the amount of differential heart rate control learned, that is, subjects who were most aware of their heart beats were generally least successful at learning to control heart rate. Whitehead, et al. hypothesize that this may have occurred because the subjective sensations associated with heart beat distracted from the mechanical feedback and provided less discriminable information than the light that signalled success.

Ikeda and Hirai (1976) investigated voluntary control of electrodermal activity in relation to both imagery (as measured by the Sophian scale of imagery) and internal perception (as measured by the Sophian Scale of Internal Perception). They found that subjects who were high both in imagery and internal perception maintained or increased their mean rate of response above the resting level over the course of training. On the other hand, the groups middle or low on both scores also increased and maintained their skin potential response (SPR) rate at or above resting level but only during the first stage of training. Thus subjects without the aid of imagery or internal perception could not maintain the increase in SPR's for a long time, whereas subjects with the aid of imagery or internal perception showed better control. There was no significant correlation found between imagery and internal perception. However, the data suggests that the combination of imagery and internal perception had a greater influence on the control of SPR's than either of the factors separately.

With the exception of the Ideda and Hirai study which is somewhat difficult to interpret due to the confounding of internal perception with imagery, it would seem that contrary to initial expectations, low autonomic perceivers more readily learn control over their autonomic processes than do high autonomic perceivers.

Anxiety level is another variable that has been investigated in relation to autonomic control. Goldenthal (1976) divided 90 male subjects into high, medium and low anxious groups of 30 each according to their scores in trait anxiety on Spielberger's State-Trait Anxiety Inventory. Subjects were then shown 20 slides of violent death victims while their GSR was continuously recorded. Subjects were instructed to keep their responses as low as possible during the viewing of the slides by thinking of something relaxing. One half of the subjects received biofeedback. On initial trials, low and high anxious subjects responded differently when given biofeedback; low anxious subjects quickly reduced their responses, while high anxious subjects had comparatively high responses. Within anxiety groups there were significant differences between subjects according to whether or not they received feedback. Low anxious subjects who received feedback had significantly lower initial responses than low anxious subjects who did not receive feedback. Conversely, high anxious subjects with feedback had significantly higher initial responses than high anxious subjects without feedback. Thus it would seem that the biofeedback training was beneficial with low anxious subjects, but only served to make high anxious subjects even more anxious.

Utz and Banikiotes (1973) investigated the relationship between anxiety and operant conditioning of alpha through biofeedback training. They used two measures of anxiety: a verbal report (Profile of Mood States) and a projective measure (The Holtzman Inkblots). They did not find significant differences in ability to enhance alpha between high and low anxious subjects as measured by verbal report. However, they did obtain significant results using the projective measure of anxiety. The low anxious group was better able to enhance alpha production through biofeedback training than was the high anxious group.

Valle, Chisolm and Degood (1975), using 40 male subjects found that the ability to suppress, as well as enhance alpha was related to lowered state and trait anxiety. The evidence from these studies investigating the relationship between anxiety level and the ability to learn autonomic control indicates that those individuals would seem to be in most need of biofeedback training (i.e., high anxious group) are least able to benefit from such training.

A couple of studies have looked at the relationship between hypnotic susceptibility and autonomic control. It was thought that those subjects who were more suggestible or had a higher degree of hypnotic susceptibility would evidence better control over their autonomic processes than less suggestible subjects. Weinstock (1974) found no correlation between hypnotic susceptibility and alpha production in a population of 27 patients. Roberts, Schuler, Bacon, Zimmerman and Patterson (1975) investigated the relationship between hypnotic susceptibility and the capacity for absorbed, imaginative attention and autonomic learning. They compared seven subjects who scored high with seven subjects who scored low on both a modified version of the Harvard Group Scale of Hypnotic Susceptibility and the Tellegen Absorption Scale. They found that neither hypnotic susceptibility nor the capacity for absorbed, imaginative attention were related to the ability to produce a difference in skin temperature in one hand relative to the other. Based upon this data, it seems unlikely that hypnotic susceptibility is related to the ability to learn autonomic control.

Several studies have looked at sex differences in heart rate control. A study by Young and Blanchard (1972) reported male superiority in ability to raise heart rate. However, another study by Zimmerman and Blankstein (1975) did not find sex related differential ability to control heart rate. Davidson and Schwartz (1976) looked at sex differences in patterns of cerebral lateralization during cardiac biofeedback versus the self regulation of emotion. Using 10 male and 10 female subjects, they compared changes in cerebral asymmetry during self control of heart rate with changes during the production of affective imagery, and studied sex differences in hemisphere function during the performance of these two tasks. EEG data indicated similar patterns of hemispheric asymmetry in both sexes during prefeedback. However, with the introduction of feedback, females shifted to a greater relative right hemisphere activation comparable to what they showed when specifically instructed to think emotional thoughts; males showed little differentiation between conditioning. This data indicates that the self-regulation of heart rate with biofeedback in males and females may be accomplished by strategies involving different underlying patterns of neurophysiological processes. At this point, it is unclear whether sex differences are related to the ability to learn autonomic control of heart rate. Even if there are no sex differences in the ability to control heart rate is is possible that differential cognitive strategies to maintain heart rate control are being used by the two sexes.

Several other factors including ego strength, authoritarianism and introspection, motor skill, and need achievement have been studied in relation to autonomic control. Stephens, Harris, Brady, and Shaffer (1976) looked at psychological and physiological variables associated with large magnitude voluntary heart rate change. They found that subjects with the highest resting heart rate variability, and highest skin potential level were best able to raise their heart rate. Subjects with the highest resting heart rate and highest resting heart rate variability were best able to decrease their heart rate. They also found that subjects with high ego strength scores (or low Welsh Factor A scores) on the MMPI were best able to control their heart rate. The ego strength score, resting heart rate, and resting heart rate variability were all significantly intercorrelated. In addition, there was a significant correlation between ability to raise and ability to lower heart rate.

Ancoli and Green (1977) looked at the relationship between authoritarianism (as measured by the California F Scale), introspection (as measured by the Edwards Personal Preference Scale) and alpha wave biofeedback training. Fifty volunteers were given personality tests measuring the traits of introspection and authoritarianism. Seven subjects from each extreme of the resulting scale were then chosen to participate. Results showed that those scoring high in introspection and low in authoritarianism could produce a larger difference between their alpha-on and alpha-off periods (thus indicating control), than those scoring low in introspection and high in authoritarianism. While subjects in both groups tended to keep alpha off by active means, a clear difference between groups emerged in the method of keeping alpha on. The group low in introspection and high in authoritarianism attempted to elevate alpha by active means, while the group high in introspection and low in authoritarianism used a passive, relaxed approach which was more successful.

Scully and Basmajian (1969) investigated the relationship between special manual skill and the time required to successfully isolate and maintain single motor units in the hand in regular, isolated activity, and to vary the rate of isolated activity on command. Contrary to expectations, the most manually skilled subjects took longer to reach the training criterion than did those subjects without manual skill.

A study by Tafts, Hon, and Blankstein (1974) investigated the relationship between need achievement and heart rate control. Using the Achieving Tendency Questionnaire, high and low achievers were selected from a pool of subjects who volunteered to participate in biofeedback experiments. They found that in general high achievers were able to effect greater control over heart rate increases with feedback, and tended to effect slightly greater although nonsignificant decreases.

Although the variables of ego strength, authoritarianism and introspection, and need achievement and their relationship with autonomic conditioning have been investigated in only one study each, it appears that they may have some relationship to the ability to learn autonomic control. It would appear that manual skill is not related to the ability to learn to control a muscular response. However, further research is needed before definative statements about the relationship of any of these variables with the ability to learn autonomic control can be made.

In summary, only three of the personality variables, locus of control, autonomic perception and anxiety level, appear to consistently differentiate between good and poor learners of autonomic control through the use of biofeedback. In general, individuals with an internal locus of control more readily learn autonomic control than those individuals with an external locus of control. Those individuals with low autonomic perception learn autonomic control better than those individuals with high autonomic perception. And lastly, low anxiety individuals exhibit greater autonomic learning than high anxiety individuals.

Research data indicates that the variables of introversion/extraversion, hypnotic susceptibility, and capacity for absorbed attention are not related to the ability to learn autonomic control.

It is difficult to say at this point whether several of the other variables studied are or are not related to learning autonomic control. For example, the two studies looking at the relationship between field dependence/independence and autonomic learning obtained opposite results.

While it is possible that there are sex differences in autonomic control, the studies investigating sex differences have employed only one autonomic modality (heart rate) and have obtained conflicting results. Ego strength, authoritarianism and introspection, and need achievement have been found to relate to learning autonomic control. Motor skill was not found to relate to learning autonomic control over individual motor units. However, only one study has been done on each of these variables. Further studies, using different autonomic modalities, are needed before it can be ascertained whether these variables are indeed related to the ability to learn autonomic control.

APPENDIX B

LIST OF ITEMS ON THE FENZ-EPSTEIN

MODIFIED ANXIETY SCALE

Autonomic Arousal Items

I am troubled by discomfort in the pit of my stomach.
I have pounding headaches in which I can feel a definite beat.
I am bothered by dizziness.
I notice my heart pounding.
I am afraid I am going to blush.
I feel chilly at temperatures that are comfortable for others.
I suddenly feel hot all over, without apparent cause.
My finger tips or other extremities become cold.
In the absence of physical action my heart beats wildly.
I am either too hot or too cold and cannot get comfortable at a constant room temperature setting.
My mouth feels dry.
I am bothered with blushing.
When embarrassed, I break out in a sweat which annoys me greatly.
I have stomach trouble.
I break out in a sweat, which is not the result of heat of physical exertion.
I am troubled with diarrhea.

Muscle Tension Items

I am troubled with backaches.
The muscles in my neck ache as if they were tied in knots.
The top of my head feels tender.
I have a hard time swallowing.
I have trouble with my hand shaking while I write.
I clench my teeth when anxious.
I am troubled by tension interfering with my speech.
I have trouble with muscles twitching and jumping.
My hands shake when I try to do something.
My skin becomes painfully sensitive.
I have pains in the back of my neck.
I am short of breath without knowing why.
I have sensations of burning, tingling, or crawling in certain parts of my body.
I have enduring headaches that last over several days.
My head feels tender to the point that it hurts when I comb my hair or put on a hat.
I have trouble getting my breath, for no special reason.
I grind my teeth in my sleep.
I have pressure headaches in which my head feels as if it were caught in a vise or as if there was a tight band around it.

Feelings of Insecurity Items

My feelings are easily hurt.
(R) I am an easy going person.
I have a tendency to worry.
I am a nervous person.
I have frightening dreams.
I do not think I am as happy as others.
I have feelings of panic for no special reason.
(R) I am a relaxed person.
I am easily frightened.
(R) I go to sleep without thoughts or ideas bothering me.
I take things hard.
(R) I take things in stride.
Life is a strain for me.
I become upset when I have to wait.
My sleep is fitful and disturbed.
I feel that I am about to go to pieces.
I worry about little things.
I have periods of such restlessness that I cannot sit still.
I become irritable about little things.

APPENDIX C

THE FENZ-EPSTEIN MODIFIED

ANXIETY SCALE

NAME: ______________________ PHONE NUMBER: ______________

INSTRUCTOR: ______________________

THE FOLLOWING ARE SOME STATEMENTS ON FEELINGS, DAYDREAMS, ATTITUDES AND BEHAVIOR. READ EACH STATEMENT AND DECIDE HOW OFTEN IT APPLIES TO YOU. CIRCLE "1" IF THE STATEMENT NEVER APPLIES TO YOU; "5" IF YOU EXPERIENCE IT ALMOST ALL THE TIME; USE "2", "3" AND "4" FOR IN BETWEEN RATINGS. BE HONEST BUT DO NOT SPEND TOO MUCH TIME OVER ANY ONE STATEMENT. AS A RULE, FIRST IMPRESSIONS ARE AS ACCURATE AS ANY.

	NEVER				ALWAYS
I am troubled by discomfort in the pit of my stomach.	1	2	3	4	5
I am troubled with backaches.	1	2	3	4	5
My feelings are easily hurt.	1	2	3	4	5
I have pounding headaches in which I can feel a definite beat.	1	2	3	4	5
The muscles in my neck ache as if they were tied in knots.	1	2	3	4	5
I am an easy-going person.	1	2	3	4	5
I am bothered by dizziness.	1	2	3	4	5
I notice my heart pounding.	1	2	3	4	5
The top of my head feels tender.	1	2	3	4	5
I have a tendency to worry.	1	2	3	4	5
I have a hard time swallowing.	1	2	3	4	5
I am a nervous person.	1	2	3	4	5
I am afraid I am going to blush.	1	2	3	4	5
I have trouble with my hand shaking while I write.	1	2	3	4	5
I have frightening dreams.	1	2	3	4	5
I feel chilly at temperatures that are comfortable for others.	1	2	3	4	5
I clench my teeth when anxious.	1	2	3	4	5
I do not think I am as happy as others.	1	2	3	4	5
I suddenly feel hot all over, without apparent cause.	1	2	3	4	5
I am troubled by tension interfering with my speech.	1	2	3	4	5
I have feelings of panic for no special reason.	1	2	3	4	5
My finger tips or other extremities become cold.	1	2	3	4	5
I have trouble with muscles twitching and jumping.	1	2	3	4	5
I am a relaxed person.	1	2	3	4	5
In the absence of physical action my heart beats wildly.	1	2	3	4	5
My hand shakes when I try to do something.	1	2	3	4	5
I am easily frightened.	1	2	3	4	5

	NEVER				ALWAYS
My mouth feels dry.	1	2	3	4	5
My skin becomes painfully sensitive.	1	2	3	4	5
I go to sleep without thoughts or ideas bothering me.	1	2	3	4	5
I am either too hot or too cold and cannot get comfortable at a costant temperature setting.	1	2	3	4	5
I have pains in the back of my neck.	1	2	3	4	5
I take things hard.	1	2	3	4	5
I am bothered with blushing.	1	2	3	4	5
I am short of breath without knowing why.	1	2	3	4	5
I take things in stride.	1	2	3	4	5
When embarrassed, I break out in a sweat which annoys me greatly.	1	2	3	4	5
I have sensations of burning, tingling, or crawling in certain parts of my body.	1	2	3	4	5
Life is a strain for me.	1	2	3	4	5
I have stomach trouble.	1	2	3	4	5
I have enduring headaches that last over several days.	1	2	3	4	5
I become upset when I have to wait.	1	2	3	4	5
I break out in sweat, which is not the result of heat or physical exertion.	1	2	3	4	5
My sleep is fitful and disturbed.	1	2	3	4	5
I am troubled with diarrhea.	1	2	3	4	5
My head feels tender to the point that it hurts when I comb my hair or put on a hat.	1	2	3	4	5
I feel that I am about to go to pieces.	1	2	3	4	5
I have trouble getting my breath, for no special reason.	1	2	3	4	5
I worry about little things.	1	2	3	4	5
I grind my teeth in my sleep.	1	2	3	4	5
I have periods of such restlessness that I cannot sit still.	1	2	3	4	5
I have pressure headaches in which my head feels as if it were caught in a vise or as if there were a tight band around it.	1	2	3	4	5
I become irritable about little things.	1	2	3	4	5

APPENDIX D

LIST OF THE ITEMS ON THE EGO STRENGTH SCALE

During the past few years I have been well most of the time.	T F
I feel unable to tell anyone all about myself.	T F
I go to church almost every week.	T F
I would certainly enjoy beating a crook at his own game.	T F
I have had very few peculiar and strange experiences.	T F
My plans have frequently seemed so full of difficulties that I have had to give them up.	T F
I am not afraid of fire.	T F
I like science.	T F
I am in just as good physical health as most of my friends.	T F
I feel sympathetic towards people who tend to hang on to their griefs and troubles.	T F
I pray several times a week.	T F
When I get bored, I like to stir up some excitement.	T F
I have strange and peculiar thoughts.	T F
I am easily downed in an argument.	T F
I am made nervous by certain animals.	T F
I think Lincoln was greater than Washington.	T F
I have never had a fainting spell.	T F
I brood a great deal.	T F
Christ performed miracles such as changing water into wine.	T F
I do many things I regret afterwards (I regret things more or more often than others seem to).	T F
I have had blank spells in which my activities were interrupted and I did not know what was going on around me.	T F
I find it hard to keep my mind on a task or job.	T F
Dirt frightens or disgusts me.	T F
I very much like horseback riding.	T F
I feel weak all over much of the time.	T F
I frequently find myself worrying about something.	T F
Everything is turning out just like the prophets of the Bible said it would.	T F
I can be friendly with people who do things I consider wrong.	T F
When I am with people, I am bothered by hearing very queer things.	T F
My way of doing things is apt to be misunderstood by others.	T F
I am afraid of finding myself in a closet or small closed place.	T F
The man who had most to do with me when I was a child (such as my father, stepfather, etc.) was very strict with me.	T F
My hands have not become clumsy or awkward.	T F
I have met problems so full of possibilities that I have been unable to make up my mind about them.	T F
I have had some very unusual religious experiences.	T F
Some people are so bossy that I feel like doing the opposite of what they request, even though I know they are right.	T F
At times I have fits of laughing or crying that I cannot control.	T F
I sometimes feel that I am about to go to pieces.	T F
I have often been frightened in the middle of the night.	T F
One or more members of my family is very nervous.	T F
I have a cough most of the time.	T F
I get mad easily and then get over it soon.	T F
I believe my sins are unpardonable.	T F
I like to flirt.	T F
I have had no difficulty in keeping my balance in walking.	T F
I feel tired a good deal of the time.	T F

In my home we always had the ordinary necessities (such as enough food, clothing, etc.). T F
I have a good appetite. T F
When I leave home, I do not worry about whether the door is locked and the windows closed. T F
I am attracted by members of the opposite sex. T F
Parts of my body often have feelings like burning, tingling, crawling, or like "going to sleep". T F
If I were an artist, I would like to draw flowers. T F
I have diarrhea once a month or more. T F
Sometimes some unimportant thought will run through my mind and bother me for days. T F
I never attend a sexy show if I can avoid it. T F
My skin seems to be unusually sensitive to touch. T F
If I were an artist, I would like to draw children. T F
At times I hear so well it bothers me. T F
Often I cross the street in order not to meet someone I see. T F
I like to talk about sex. T F
I like collecting flowers or growing house plants. T F
I seldom worry about my health. T F
I dream frequently about things that are best kept to myself. T F
I do not like to see women smoke. T F
I like to cook. T F
My sleep is fitful and disturbed. T F
Sometimes I enjoy hurting persons I love. T F
When someone says silly or ignorant things about something I know, I try to set him right. T F

APPENDIX E

CORRELATION MATRIX FOR BOTH GROUPS COMBINED

	FEPRS	ANX	ES	GSRB	EMGB	GSRD	EMGD	GRSL	EMGL
FEPRS		0.0299 (20) S=0.450	0.0938 (20) S=0.347	-0.1442 (20) S=0.272	0.1303 (20) S=0.292	-0.1193 (20) S=0.308	-0.1400 (20) S=0.278	-0.1194 (20) S=0.308	-0.0804 (20) S=0.368
ANX			-0.3457 (20) S=0.068	0.3055 (20) S=0.095	0.3493 (20) S=0.026	0.1872 (20) S=0.215	0.3246 (20) S=0.081	0.3452 (20) S=0.068	0.4719 (20) S=0.018
ES				0.1544 (20) S=0.258	0.1208 (20) S=0.306	0.2167 (20) S=0.179	0.1284 (20) S=0.295	-0.0217 (20) S=0.464	0.0294 (20) S=0.451
GSRB					0.2543 (20) S=0.140	0.8855 (20) S=0.001	0.2400 (20) S=0.154	0.7010 (20) S=0.001	0.0760 (20) S=0.375
EMGB						0.3581 (20) S=0.061	0.9687 (20) S=0.001	-0.0323 (20) S=0.446	0.2474 (20) S=0.146
GSRD							0.3830 (20) S=0.048	0.2900 (20) S=0.107	-0.0594 (20) S=0.402
EMGD								-0.0989 (20) S=0.339	0.0065 (20) S=0.489
GSRL									0.2419 (20) S=0.152
EMGL									

Note: FEPRS = Fenz-Epstein Physiological Reactivity Score, ANX = Anxiety, ES = Ego Strength, GSRB = GSR Baseline, EMGB = EMG Baseline, GSRD = GSR Difference, EMGD = EMG Difference, GSRL = GSR Lowest Level, EMGL = EMG Lowest Level.

APPENDIX F

CORRELATION MATRIX FOR THE MUSCLE

TENSION GROUP

	FEPRS	ANX	ES	GSRB	EMGB	GSRD	EMGD	GRSL	EMGL
FEPRS		-0.6492 (10) S=0.021	0.5747 (10) S=0.041	0.3888 (10) S=0.133	-0.0985 (10) S=0.393	0.4662 (10) S=0.087	0.2066 (10) S=0.283	0.0765 (10) S=0.417	-0.5022 (10) S=0.070
ANX			-0.3834 (10) S=0.137	0.1127 (10) S=0.378	-0.2036 (10) S=0.286	-0.0628 (10) S=0.432	-0.5419 (10) S=0.053	0.3360 (10) S=0.171	0.6390 (10) S=0.023
ES				0.5495 (10) S=0.050	0.5370 (10) S=0.055	0.6699 (10) S=0.017	0.6497 (10) S=0.021	0.0937 (10) S=0.398	-0.3364 (10) S=0.171
GSRB					0.2223 (10) S=0.268	0.8902 (10) S=0.001	0.2054 (10) S=0.285	0.6928 (10) S=0.013	-0.0292 (10) S=0.468
EMGB						0.3213 (10) S=0.183	0.8168 (10) S=0.002	-0.0401 (10) S=0.456	0.0539 (10) S=0.441
GSRD							0.3164 (10) S=0.187	0.2882 (10) S=0.210	-0.0762 (10) S=0.417
EMGD								-0.0694 (10) S=0.424	-0.5321 (10) S=0.057
GSRL									0.0613 (10) S=0.433
EMGL									

Note: FEPRS = Fenz-Epstein Physiological Reactivity Score, ANX = Anxiety, ES = Ego Strength, GSRB = GSR Baseline, EMGB = EMG Baseline, GSRD = GSR Difference, EMGD = EMG Difference, GSRL = GSR Lowest Level, EMGL = EMG Lowest Level.

APPENDIX G

CORRELATION MATRIX FOR THE AUTONOMIC GROUP

	FEPRS	ANX	ES	GSRB	EMGB	GSRD	EMGD	GRSL	EMGL
FEPRS		-0.0504 (10) S=0.445	0.4951 (10) S=0.073	0.0247 (10) S=0.473	-0.2132 (10) S=0.277	-0.3827 (10) S=0.138	-0.3632 (10) S=0.151	0.6170 (10) S=0.029	0.7221 (10) S=0.009
ANX			-0.2888 (10) S=0.209	0.8119 (10) S=0.002	0.8024 (10) S=0.003	0.7647 (10) S=0.005	0.7740 (10) S=0.004	0.4586 (10) S=0.001	0.2947 (10) S=0.204
ES				-0.5472 (10) S=0.051	0.0374 (10) S=0.459	-0.5724 (10) S=0.042	-0.0269 (10) S=0.471	-0.2237 (10) S=0.267	0.4564 (10) S=0.092
GSRB					0.4822 (10) S=0.079	0.8654 (10) S=0.001	0.4584 (10) S=0.091	0.6829 (10) S=0.015	0.1997 (10) S=0.290
EMGB						0.6178 (10) S=0.029	0.9830 (10) S=0.001	0.0153 (10) S=0.483	0.3882 (10) S=0.134
GSRD							0.6588 (10) S=0.019	0.2263 (10) S=0.265	-0.0800 (10) S=0.413
EMGD								-0.0874 (10) S=0.405	0.2229 (10) S=0.268
GSRL									0.4801 (10) S=0.080
EMGL									

Note: FEPRS = Fenz-Epstein Physiological Reactivity Score, ANX = Anxiety, ES = Ego Strength, GSRB = GSR Baseline, EMGB = EMG Baseline, GSRD = GSR Difference, EMGD = EMG Difference, GSRL = GSR Lowest Level, EMGL = EMG Lowest Level.

VITA 2

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Doctor of Philosophy

Thesis: THE EFFECT OF INDIVIDUAL DIFFERENCES IN PHYSIOLOGICAL REACTIVITY ON LEARNING CONTROL OF EMG AND GSR RESPONSES THROUGH BIOFEEDBACK TRAINING

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